

## SYNTHESIS OF NOVEL POLYCYCLIC RING SYSTEMS CONTAINING TWO PYRANO[2,3-*c*]PYRAZOL-4-(1H)ONE MOIETIES

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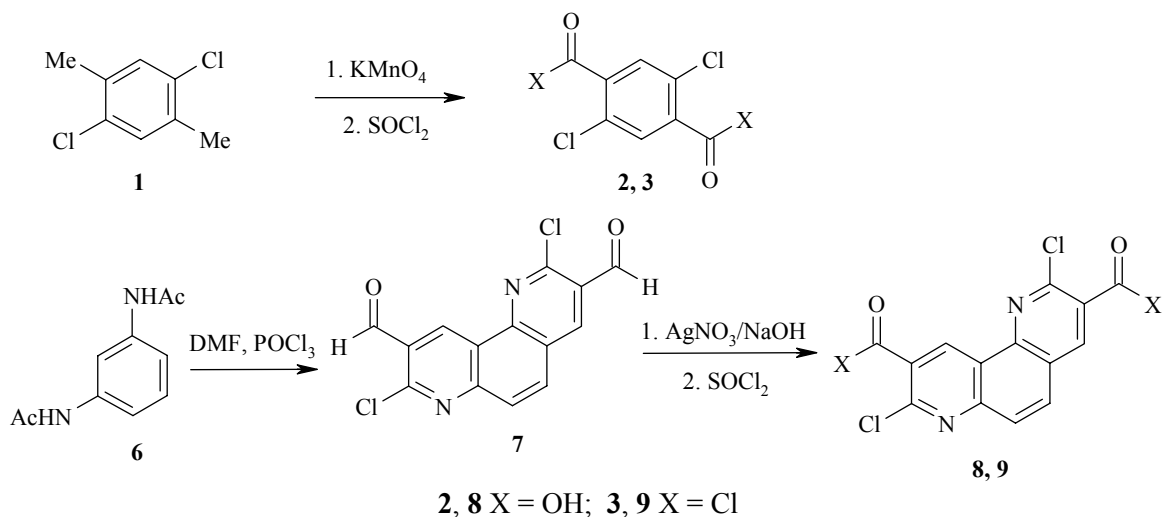
Novel penta- or heptacyclic ring systems containing two pyrano[2,3-*c*]pyrazol-4(1H)-one units are prepared in one or two steps from the reaction of 3-methyl-1-phenyl-2-pyrazolin-5-one and bis(*o*-chlorocarbonyl chlorides) derived from benzene- or 1,10-phenanthroline.

**Keywords:** pyrazolones fused ring systems, acylations.

Recently, we presented a short and efficient synthesis of novel azaxanthenes containing a pyrano[2,3-*c*]pyrazol-4(1H)-one moiety by the reaction of 1-substituted 2-pyrazolin-5-ones with *o*-halo-(hetero)arene carbonyl chlorides [1-4]. In continuation of these investigations we here report on the related preparation of hitherto unknown polyheterocycles, which contain two units of the above-mentioned substructure.

Hence, as the acid chloride reactants we have chosen the dicarbonyl dichlorides **3** and **9**, which were synthesized as outlined in Scheme 1, applying slight modifications of the procedures described in the literature.

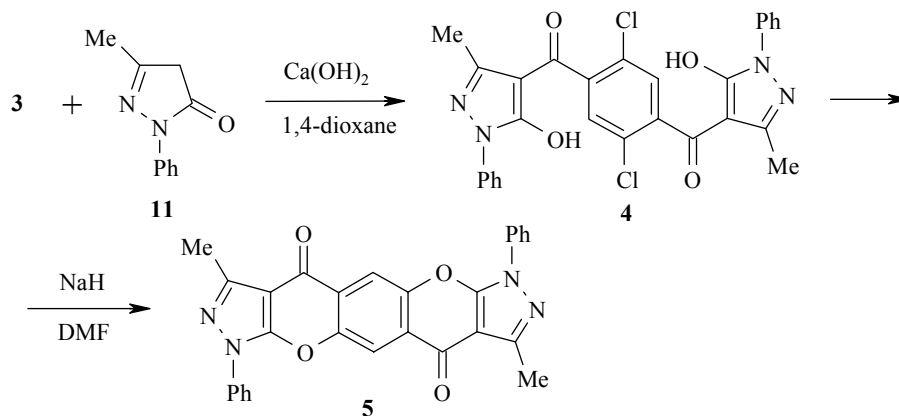
Scheme 1



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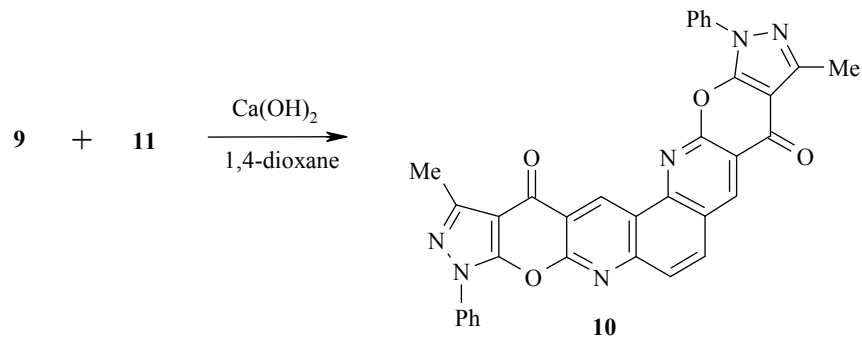
When the terephthaloyl dichloride **3** reacted with pyrazolone **11** under the typical conditions reported by Jensen [5] ( $\text{Ca}(\text{OH})_2$ , refluxing 1,4-dioxane), (Scheme 2) we isolated the expected 4-arylpyrazol-5-ol **4**. The latter was subsequently converted into the pentacycle **5** by treatment with NaH in refluxing DMF. The total yield over two steps (starting from the dicarbonyl dichloride **3**) was 23%.

Scheme 2



The reaction of pyrazolone **11** with the phenanthrolinedicarbonyl dichloride **9** under Jensen-type reaction conditions directly led to the target heptacycle **10** in 11% yield (Scheme 3). Such type of spontaneous intramolecular cyclization of the intermediate 4-arylpyrazol-5-ols has been previously observed with some related pyridinecarbonyl chlorides [1, 3, 4].

Scheme 3



## EXPERIMENTAL

Melting points were determined on a Reichert–Kofler hot-stage microscope and are uncorrected. Mass spectra were obtained on a Shimadzu QP 1000 instrument (EI, 70 eV). IR spectra were recorded on a Perkin–Elmer FTIR 1605 spectrophotometer in KBr. Elemental analyses were performed at the Microanalytical Laboratory, University of Vienna. The  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra were recorded on a Varian UnityPlus 300 spectrometer at 28°C or on a Bruker Avance 500 spectrometer at 293 K. The center of the solvent signal ( $\text{DMSO-d}_6$ ) was used as an internal standard which was related to TMS. The digital resolutions were 0.2 Hz/data point in the  $^1\text{H}$  NMR spectra and 0.4 Hz/data point in the  $^{13}\text{C}$  NMR spectra ( $^1\text{H}$  broadband decoupling or gated decoupling).  $^{15}\text{N}$  NMR spectra were obtained on a Bruker Avance 500 instrument with a directly

detecting broadband observe probe and were referenced against external nitromethane (coaxial capillary). It is important to note that owing to the very low solubility or the even practical insolubility of compounds **3-5,7,9** and **10** in common NMR solvents such as DMSO- $d_6$  or  $CDCl_3$  only limited NMR spectroscopic investigations were possible. Systematic names were generated with ACD/Name [6] according to the IUPAC recommendations and were also checked manually to ensure the correct use of nomenclature within this publication [7]. The alternative name for compound **4** is according to phane nomenclature [8, 9]. Product yields were not optimized.

**1,4-Dichloro-2,5-dimethylbenzene (1)**. This product is commercially available (Aldrich).  $^1H$  NMR spectrum (300 MHz),  $\delta$ , ppm: 7.38 (2H, s, H-3,6); 2.25 (6H, s,  $CH_3$ ).  $^{13}C$  NMR spectrum (75 MHz),  $\delta$ , ppm ( $J$ , Hz): 134.7, 131.5, 130.8 (C-3,6;  $^1J = 165.5$ ), 18.7 ( $CH_3$ ,  $^1J = 128.4$ ).

**2,5-Dichloroterephthalic Acid (2)**. To a well stirred suspension of 1 g Aliquat<sup>®</sup> 336 (trioctylmethylammonium chloride) of  $KMnO_4$  (4.74 g, 30 mmol) and of xylene **1** (5.25 g, 30 mmol) in  $H_2O$  (50 ml) was added dropwise a solution of  $KMnO_4$  (14.2 g, 90 mmol) in  $H_2O$  (150 ml). Then the reaction mixture was heated to 80°C for 72 h. After cooling the mixture to room temperature, it was filtered off and the remaining filter cake was extracted twice with 30 ml of  $Et_2O$ . The combined organic layers were washed with  $H_2O$  (10 ml), dried over anhydrous  $Na_2SO_4$ , and the solvent was removed under reduced pressure to afford of unreacted starting material **1** (1.10 g, 21%). The filtrate was treated with small amounts of  $NaHSO_3$  and brought to pH 1 by dropwise addition of 2N HCl. Upon cooling in the refrigerator overnight colorless crystals of **2** separated, which were filtered off and dried. Yield 4.52 g (64%; 81% based upon unrecovered educt). Alternatively, this product can be obtained from TCI Europe Organic Chemicals.  $^1H$  NMR spectrum (300 MHz),  $\delta$ , ppm: 13.71 (2H, br. s, OH); 7.89 (2H, s, H-3,6).  $^{13}C$  NMR spectrum (75 MHz),  $\delta$ , ppm ( $J$ , Hz): 164.9 (CO), 134.8, 132.1 (C-3,6;  $^1J = 171.3$ ), 130.0. MS,  $m/z$  ( $I_{rel}$ , %): 238  $[M]^+$  (10), 236  $[M]^+$  (75), 234  $[M]^+$  (100), 221 (11), 219 (62), 217 (90), 135 (23), 133 (32), 109 (21), 74 (51), 73 (27), 45 (26).

**2,5-Dichloroterephthaloyl Dichloride (3)**. A suspension of terephthalic acid **2** (2.35 g, 10 mmol), cyclohexane (5 ml), DMF (1 drop), and  $SOCl_2$  (15 ml) was heated at reflux for 4 h. Excess  $SOCl_2$  was removed under reduced pressure, and the reaction mixture was refrigerated overnight and then filtered off to afford the acid chloride **3**. Yield 2.20 g (81%); mp 77.5-79°C (mp 80.5-81°C [10]). MS,  $m/z$  ( $I_{rel}$ , %): 276  $[M]^+$  (1), 274  $[M]^+$  (5), 272  $[M]^+$  (11), 270  $[M]^+$  (8), 239 (28), 237 (100), 235 (91), 209 (39), 207 (37), 109 (28), 74 (43), 73 (24).

**(2,5-Dichloro-1,4-phenylene)bis[(5-hydroxy-3-methyl-1-phenyl-1H-pyrazol-4-yl)methanone] (4)**. To a suspension of pyrazolone **11** (697 mg, 4 mmol) and  $Ca(OH)_2$  (593 mg, 8 mmol) in 1,4-dioxane (6 ml) was added the acid chloride **3** (544 mg, 2 mmol), suspended in 1,4-dioxane (2 ml), and the reaction mixture was heated at reflux for 3 h. After cooling to room temperature, the mixture was treated with 2N HCl (16 ml) and then stirred for 1 h before it was poured onto  $H_2O$  (40 ml). After 30 min, the mixture was filtered off and the remaining solid was repeatedly washed with  $H_2O$  to give crude compound **4** (510 mg, 47%). For analytical purposes 100 mg were recrystallized from  $EtOH-DMF$ . Mp 262-268°C. IR spectrum,  $\nu$ ,  $cm^{-1}$ : 1622 (C=O).  $^1H$  NMR spectrum (500 MHz),  $\delta$ , ppm: 7.63 (4H, m, NPh H-2,6); 7.51 (2H, s, Ph H-3,5); 7.46 (4H, m, NPh H-3,5); 7.29 (2H, m, NPh H-4); 2.28 (6H, s,  $CH_3$ ).  $^{13}C$  NMR spectrum (125 MHz),  $\delta$ , ppm: 185.1 (CO), 141.9 ( $C_q$ ), 136.8 (NPh C-1), 129.0 (NPh C-3,5), 128.6 (Ph C-3,6), 128.1 ( $C_q$ ), 126.2 (NPh C-4), 121.0 (NPh C-2,6), 104.0 (pyrazole C-4), 14.2 ( $CH_3$ ). MS,  $m/z$  ( $I_{rel}$ , %): 550  $[M]^+$  (5), 548  $[M]^+$  (30), 546  $[M]^+$  (30), 513 (26), 511 (54), 475 (45), 355 (36), 327 (32), 325 (77), 311 (40), 238 (26), 201 (32), 92 (29), 91 (76), 88 (64), 77 (100), 67 (69), 58 (35), 43 (40). Found, %: C 60.95; H 3.58; N 10.25.  $C_{28}H_{20}Cl_2N_4O_4 \cdot 0.2H_2O$ . Calculated, %: C 60.94; H 3.74; N 10.15.

**3-9-Dimethyl-1,7-diphenylbenzo[1'',2'':5',6';4'',5'':5'6']dipyrano[2,3:d;2',3':d']dipyrazole-4,10(1H,7H)-dione (5)**. Under anhydrous conditions, a suspension of compound **4** (274 mg, 0.5 mmol) and NaH (50% in mineral oil, 44 mg, 1 mmol) in DMF (3 ml) was heated at reflux overnight. Then the solvent was removed under reduced pressure and  $H_2O$  (5 ml) was added to the residue. The mixture was stirred for 1 h and the precipitate

formed was filtered off, washed with H<sub>2</sub>O and petroleum ether, and recrystallized from DMF to afford the pure pentacycle **5**. Yield 94 mg (49%); mp > 340°C. IR spectrum,  $\nu$ , cm<sup>-1</sup>: 1668 (C=O). <sup>1</sup>H NMR spectrum (300 MHz),  $\delta$ , ppm: 8.51 (2H, s, H-5,11); 8.03 (4H, m, NPh H-2,6); 7.65 (4H, m, NPh H-3,5); 7.48 (2H, m, NPh H-4); 2.62 (6H, s, CH<sub>3</sub>). MS,  $m/z$  ( $I_{\text{rel}}$ , %): 475 [M]<sup>+</sup> (26), 474 (79), 473 (23), 121 (100), 77 (35). Found, %: C 70.58; H 3.72; N 11.78. C<sub>28</sub>H<sub>18</sub>N<sub>4</sub>O<sub>4</sub>. Calculated, %: C 70.88; H 3.82; N 11.81.

**N,N'-(1,3-Phenylene)diacetamide (6)**. Similarly to the known procedure [11], to molten 1,3-benzene-diamine (54.1 g, 0.5 mol) was added dropwise Ac<sub>2</sub>O (76.6 g, 0.75 mol) under stirring. The solution was heated to reflux for 2 h, then further Ac<sub>2</sub>O (25.5 g, 0.25 mol) was added, and the reaction mixture was again refluxed for 2 h. The solution was cooled to room temperature and then poured into H<sub>2</sub>O (ca. 300 ml) under stirring. Upon standing in the refrigerator for 1 h, diacetamide **6** separated as almost colorless crystals, which were dried at 90°C for 1 h. Yield 89.5 g (93%); mp 186-189°C (mp 191°C [12]). <sup>1</sup>H NMR spectrum (300 MHz),  $\delta$ , ppm: 9.89 (2H, s, NH); 7.87 (1H, br. s, H-2); 7.25 (2H, m, H-4,6); 7.16 (1H, m, H-5); 2.02 (6H, s, CH<sub>3</sub>). <sup>13</sup>C NMR (75 MHz):  $\delta$  168.2 (CO), 139.5 (C-1,3), 128.7 (C-5), 113.8 (C-4,6), 109.8 (C-2), 24.0 (CH<sub>3</sub>). MS,  $m/z$  ( $I_{\text{rel}}$ , %): 192 [M]<sup>+</sup> (21), 150 (32), 108 (100), 80 (31), 43 (100).

**2,8-Dichloro-1,7-phenanthroline-3,9-dicarbaldehyde (7)**. Similarly to the known procedure [13], POCl<sub>3</sub> (107 g, 0.7 mol) was added dropwise to DMF (21.9 g, 0.3 mol) at 0°C under stirring. To this solution was added the diacetamide **6** (9.61 g, 0.05 mol) and the resulting mixture was refluxed for 4 h. The deeply colored solution was cooled to room temperature and added dropwise to ice water (ca. 500 ml) with stirring. Then the pH was adjusted to 2–3 by addition of 2 N NaOH to precipitate phenanthroline **7**, which was filtered off and washed with H<sub>2</sub>O and light petroleum to afford a yellowish powder. Yield 10.9 g (71%). IR spectrum,  $\nu$ , cm<sup>-1</sup>: 1685-1695 (2×C=O). <sup>1</sup>H NMR spectrum (300 MHz),  $\delta$ , ppm ( $J$ , Hz): 10.47 (1H, s, 9-CHO); 10.45 (1H, s, 3-CHO); 9.68 (1H, d, <sup>5</sup> $J_{10,6}$  = 0.7, H-10); 9.15 (1H, s, H-4); 8.62 (1H, d, <sup>3</sup> $J_{5,6}$  = 9.1, H-5); 8.17 (1H, dd, <sup>3</sup> $J_{6,5}$  = 9.1, <sup>5</sup> $J_{6,10}$  = 0.7, H-6). MS,  $m/z$  ( $I_{\text{rel}}$ , %): 308 [M]<sup>+</sup> (4), 307 (19), 306 [M]<sup>+</sup> (59), 305 (56), 304 [M]<sup>+</sup> (100), 303 (65), 275 (36), 240 (43), 211 (39), 177 (59), 176 (85), 151 (78), 150 (56), 124 (47), 123 (44), 100 (33), 99 (39), 75 (36), 74 (35).

**2,8-Dichloro-1,7-phenanthroline-3,9-dicarboxylic Acid (8)**. Similarly to the known procedure [13], to dialdehyde **7** (6.10 g, 20 mmol), suspended in EtOH (96%, 3200 ml), was added AgNO<sub>3</sub> (13.6 g, 80 mmol), dissolved in aqueous EtOH (80%, 200 ml). To the clear solution was added in small portions NaOH (10.0 g, 250 mmol), dissolved in aqueous EtOH (80%, 200 ml), and the dark reaction mixture was stirred at room temperature for 4 h. Then Ag<sub>2</sub>O was filtered off and the filtrate was concentrated almost to dryness under reduced pressure. Water (ca. 50 ml) was added and the solution was filtered again. Upon acidification of the solution by dropwise addition of conc. HCl a precipitate formed, which was filtered off, washed with H<sub>2</sub>O, and dried to give the yellow acid **8**, which was used without further purification in the next reaction step. Yield 2.97 g (44%); mp >320°C. <sup>1</sup>H NMR spectrum (300 MHz),  $\delta$ , ppm ( $J$ , Hz): 9.50 (1H, s, H-10); 9.01 (1H, s, H-4); 8.36 (1H, d, <sup>3</sup> $J_{5,6}$  = 9.1, H-5); 7.98 (1H, d, <sup>3</sup> $J_{6,5}$  = 9.1, H-6). <sup>13</sup>C NMR spectrum (75 MHz),  $\delta$ , ppm: 165.3 (3-COOH), 165.1 (9-COOH), 149.9 (C-6a), 149.7 (C-8), 147.9 (C-2), 144.9 (C-10b), 141.4 (C-4), 137.2 (C-10), 132.4 (C-5), 127.8 (C-6), 127.1\* (C-3), 125.9\* (C-9), 124.6\* (C-4a), 122.9\* (C-10a); <sup>15</sup>N NMR spectrum (50 MHz),  $\delta$ , ppm: -77.2 (N-7), -86.0 (N-1).

**2,8-Dichloro-1,7-phenanthroline-3,9-dicarbonyl Dichloride (9)**. A suspension of diacid **8** (1.69 g, 5 mmol), cyclohexane (5 ml), DMF (1 drop), and SOCl<sub>2</sub> (10 ml) was heated at reflux for 6 h. Then excess SOCl<sub>2</sub> was removed under reduced pressure and the reaction mixture was stored in the refrigerator overnight. The precipitated crystals were filtered off to afford the pure acid chloride **10**. Yield 1.56 g (84%). IR spectrum,  $\nu$ , cm<sup>-1</sup>: 1748–1761 (2×C=O). MS,  $m/z$  ( $I_{\text{rel}}$ , %): 376 [M]<sup>+</sup> (3), 374 [M]<sup>+</sup> (7), 372 [M]<sup>+</sup> (6), 341 (36), 339 (97), 337 (100), 151 (25), 123 (37), 105 (25). Found, %: C 45.07; H 1.29; N 7.59. C<sub>14</sub>H<sub>4</sub>Cl<sub>4</sub>N<sub>2</sub>O<sub>4</sub>. Calculated, %: C 44.96; H 1.08; N 7.49.

\* Unambiguous differentiation between C-3/C-9 and between C-4a/C-10a was not possible.

**3,12-Dimethyl-1,10-diphenylbis(pyrazolo[4',3':5,6]pyrano)[2,3-b:2',3'-j][1,7]phenanthroline-4,13(1H,10H)dione (10)**. To a suspension of pyrazolone **11** (348 mg, 2 mmol) and Ca(OH)<sub>2</sub> (296 mg, 4 mmol) in 1,4-dioxane (3 ml) was added acid chloride **9** (374 mg, 1 mmol), suspended in 1,4-dioxane (2 ml), and the reaction mixture was heated at reflux for 3 h. After cooling to room temperature, the mixture was treated with 2N HCl (8 ml) and then stirred for 1 h before it was poured onto H<sub>2</sub>O (20 ml). After 30 min, the mixture was filtered and the remaining solid was repeatedly washed with H<sub>2</sub>O. Recrystallization from DMF afforded the pure heptacycle **10**. Yield 64 mg (11%); mp >340°C. IR spectrum,  $\nu$ , cm<sup>-1</sup>: 1669-1683 (2×C=O). MS,  $m/z$  ( $I_{rel}$ , %): 577 [M + 1]<sup>+</sup> (12), 576 [M]<sup>+</sup> (14), 91 (45), 77 (73), 44 (100), 41 (37). Found, %: C 69.60; H 3.26; N 14.50. C<sub>34</sub>H<sub>20</sub>N<sub>6</sub>O<sub>4</sub> • ½H<sub>2</sub>O. Calculated, %: C 69.74; H 3.61; N 14.35.

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